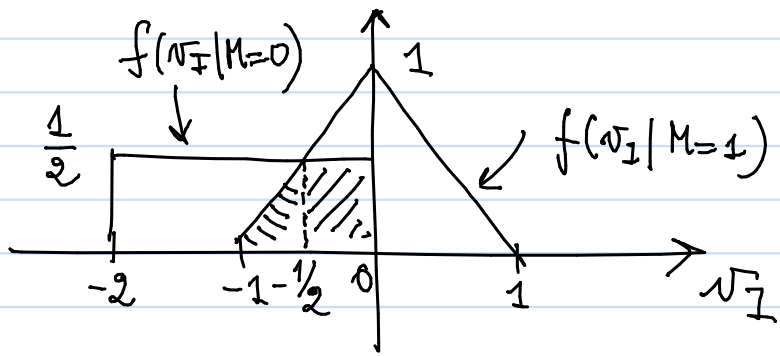


1.

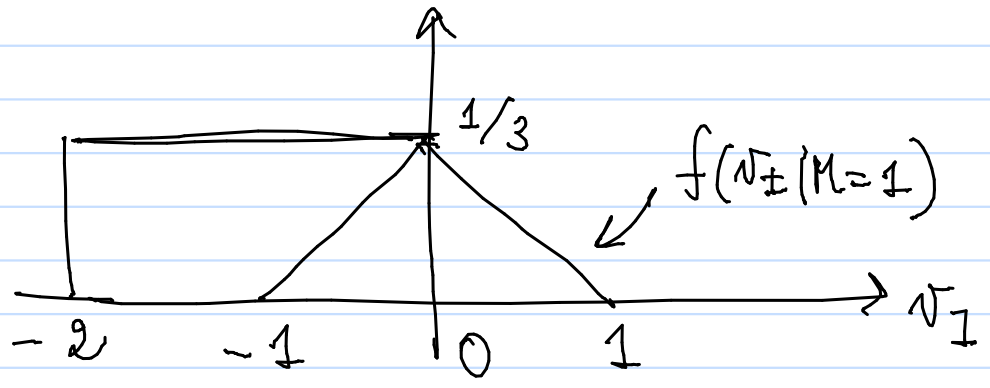


a. $\gamma = -1/2$

b.
$$P_B(E) = \frac{1}{2} \underbrace{\left(\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} \right)}_{\Pr(\hat{M}=0|M=1)} + \frac{1}{2} \underbrace{\left(\frac{1}{2} \cdot \frac{1}{2} \right)}_{\Pr(\hat{M}=1|M=0)}$$

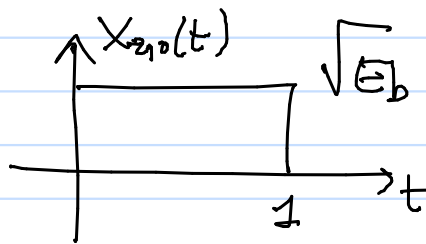
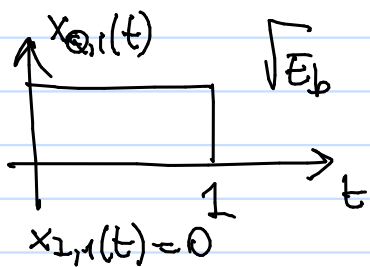
$$= \frac{1}{16} + \frac{1}{8} = \frac{3}{16}$$

c.



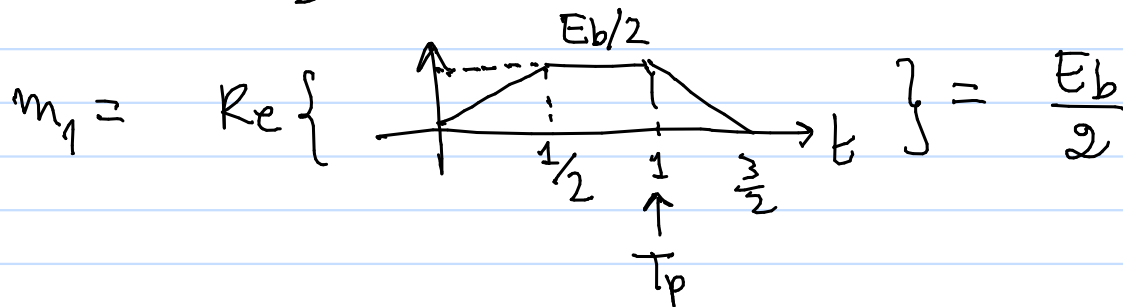
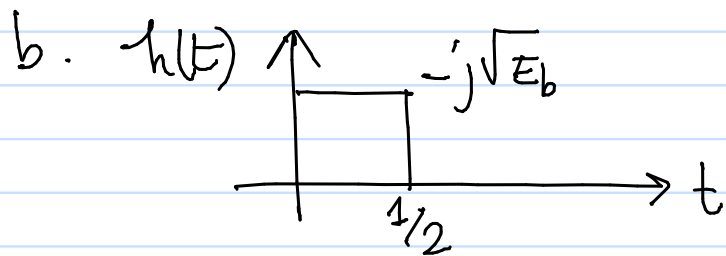
$\gamma = 0$

2.



a. Constellation

$$\Omega_d = \{1, j\}$$



$$m_0 = 0$$

$$\sigma_{N_I}^2 = \frac{N_0}{2} E_b \frac{1}{2} = \frac{N_0 E_b}{4}$$

c. $P_b(E) = Q \left(\frac{m_1 - m_0}{2 \sigma_{N_I}} \right) = Q \left(\frac{E_b}{4 \sqrt{\frac{N_0 E_b}{4}}} \right) = Q \left(\sqrt{\frac{E_b}{4 N_0}} \right)$

d. Matched filter

$$h(t) = x_e^*(-t + T_p) = \begin{cases} -j - 1 & \text{for } 0 \leq t \leq T_p \\ 0 & \text{elsewhere} \end{cases}$$

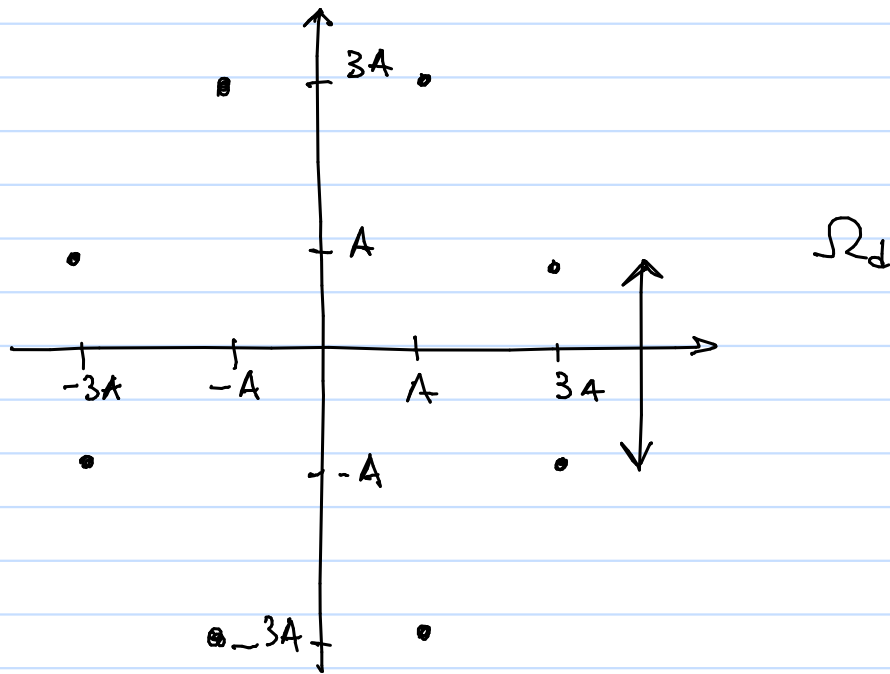
e. Probability of error with matched filter:

$$P_b(E) = Q\left(\sqrt{\frac{E_b}{N_0}}\right)$$

since they are orthogonal waveforms ($\text{Re}(\rho) = 0$)

\Rightarrow loss of suboptimal filter $10 \log_{10} 4 = 6 \text{ dB}$.

3.



$$a. \quad 3 = 9A^2 + A^2 = 10A^2 \Rightarrow A = \sqrt{\frac{3}{10}}$$

$$b. \quad \Delta E(\min) = E_b |2A|^2 = 4A^2 E_b = 4 \frac{3}{10} E_b$$

$$= \frac{6}{5} E_b$$

$$\Rightarrow P_w(E) \approx \frac{1}{8} \mathcal{Q} \left(\sqrt{\frac{3E_b}{5N_0}} \right)$$